Attorney Docket No. 7593 P1

CLAIMS

In the claims:

1. (Original) A method of monitoring biofouling in a membrane separation system including a membrane capable of separating a feed stream into at least a first stream, known as the permeate, and a second stream, known as the concentrate, comprising the steps of:

(a) selecting a fluorogenic agent wherein the selection is made such that it is known in advance whether said fluorogenic agent is

(i) capable of traveling through the membrane into the permeate stream, or

(ii) not capable of passing through the membrane into the permeate stream;

(b) adding the fluorogenic agent to the feed stream;

(c) providing one or more fluorometers to detect the fluorescent signal of the fluorogenic agent in at least one of the feed stream, the concentrate and optionally the permeate;

(d) allowing the fluorogenic agent to react with at least one microorganism within the membrane separation system to form a reacted fluorogenic agent;

(e) using said one or more fluorometers to detect the fluorescent signal of at least one of the fluorogenic agent and the reacted fluorogenic agent in at least one of the feed stream and the concentrate and optionally the permeate; and

(f) using the fluorescent signal of at least one of the fluorogenic agent and the reacted fluorogenic agent to monitor biofouling in the membrane separation system based on the change in the fluorescent signal of the fluorogenic agent, or the reacted fluorogenic agent or a combination of both fluorescent signals.

2. (Original) The method of claim 1 wherein the membrane separation system is selected from the group consisting of a cross-flow membrane separation system and a dead-end flow membrane separation system.

3. (Original) The method of claim 1 wherein the membrane separation system is selected from the group consisting of reverse osmosis, nanofiltration, ultrafiltration, microfiltration, electrodialysis, electrodeionization, pervaporation, membrane extraction, membrane distillation, membrane stripping, membrane aeration and combinations thereof.

4. (Original) The method of claim 1 wherein the fluorogenic agent is selected from the group consisting of:

acetic acid ester of pyrene 3,6,8-trisulfonic acid;

3-carboxyumbelliferyl β-D-galactopyranoside;

3-carboxyumbelliferyl β -D-glucuronide;

9H-(1,3-dichloro-9,0-dimethylacridine-2-one-7-yl), D-glucuronide;

resorufin β -D-galactopyranoside;

resazurin;

resazurin, sodium salt;

4-methylumbelliferyl phosphate;

and combinations thereof.

5. (Original) The method of claim 1 wherein the fluorogenic agent is resazurin.

6. (Original) The method of claim 1 wherein the fluorogenic agent is added into the feed stream in an amount from about 5 ppt to 500 ppm.

7. (Original) The method of claim 1 wherein biofouling is monitored by determining a ratio of the fluorescent signal of the reacted fluorogenic agent to the fluorescent signal of the fluorogenic agent in at least one of the permeate and concentrate.

8. (Original) The method of claim 1 further comprising the step of:

(g) determining the optimal amount of biocontrol treatment based on the change in the signal of the fluorogenic agent, or the reacted fluorogenic agent, or a combination of both signals measured; and

(h) applying the optimal amount of biocontrol treatment to the membrane separation system.

9. (Original) The method of claim 8 wherein the biocontrol treatment is selected from the group consisting of biocides, biocontrol agents, biocontrol methods and combinations thereof.

10. (Original) The method of claim 8 wherein the biocides are selected from the group consisting of:

oxidizing biocides, non-oxidizing biocides and combinations thereof.

11. (Original) The method of claim 8 wherein the biocontrol treatment is selected from the group consisting of:

bio-dispersants, bio-detergents, chaotropic agents, surfactants, chelating agents, enzymatic cleaners and combinations thereof.

12. (Original) The method of claim 8 wherein the biocontrol treatment is selected from the group consisting of:

ultrasound, electric fields and air backwashes.

13. (Original) The method of claim 1 wherein the microorganisms are selected from the group consisting of planktonic microorganisms, sessile microorganisms and combinations thereof.

14. (Original) The method of claim 1 in which the feed stream is aqueous.

15. (Original) The method of claim 1 in which the feed stream is non-aqueous.

16. (Original) A method of monitoring biofouling in a membrane separation system including a membrane capable of separating a feed stream into at least a first stream, known as the permeate, and a second stream, known as the concentrate, comprising the steps of:

(a) selecting a fluorogenic agent wherein the selection is made such that it is known in advance whether said fluorogenic agent is

(i) capable of traveling through the membrane into the permeate stream, or

(ii) not capable of passing through the membrane into the permeate stream;

(b) selecting an inert fluorescent tracer wherein the selection is made such that it is known in advance whether said inert fluorescent tracer is

(i) capable of traveling through the membrane into the permeate stream, or

(ii) not capable of passing through the membrane into the permeate stream;

(c) adding the fluorogenic agent and the inert fluorescent tracer to the feed stream, wherein said fluorogenic agent and said inert fluorescent tracer are added in a known proportion to each other;

(d) providing one or more fluorometers to detect the fluorescent signal of the fluorogenic agent and the fluorescent signal of the inert fluorescent tracer in at least one of the feed stream or the concentrate or optionally the permeate;

(e) allowing the fluorogenic agent to react with at least one microorganism within the membrane separation system to form a reacted fluorogenic agent;

(f) using said one or more fluorometers to detect the fluorescent signal of at least one of the fluorogenic agent and the reacted fluorogenic agent and the inert fluorescent tracer in at least one of the feed stream and the

concentrate and optionally the permeate; and

(g) using the fluorescent signal of at least one of the fluorogenic agent and the reacted fluorogenic agent and the inert fluorescent tracer to monitor biofouling in the membrane separation system based on the change in the fluorescent signal of the fluorogenic agent, or the reacted fluorogenic agent or a combination of both fluorescent signals relative to the fluorescent signal of the inert fluorescent tracer.

17. (Original) The method of Claim 16 in which said inert tracer is selected from the group consisting of the mono-, di- and tri-sulfonated naphthalenes, including their known water-soluble salts; the sulfonated derivatives of pyrene, including 1,3,6,8-pyrenetetrasulfonic acid, along with the known water-soluble salts of all of these materials and 1H-Benz(de) isoquinoline-5-sulfonic acid, 6-amino-2,3-dihydro-1,3-dioxo-2-p-tolyl-, monosodium salt (8CI)).

18. (Original) The method of claim 16 wherein the fluorogenic agent is selected from the group consisting of:

acetic acid ester of pyrene 3,6,8-trisulfonic acid;

3-carboxyumbelliferyl β-D-galactopyranoside;

3-carboxyumbelliferyl β -D-glucuronide;

9H-(1,3-dichloro-9,0-dimethylacridine-2-one-7-yl), D-glucuronide;

resorufin β -D-galactopyranoside;

resazurin;

resazurin, sodium salt;

4-methylumbelliferyl phosphate;

and combinations thereof.

19. (Original) The method of claim 16 wherein the fluorogenic agent is resazurin.

20. (Original) The method of claim 16 further comprising the steps of:

(a) determining the optimal amount of biocontrol treatment based on the change in the signal of the fluorogenic agent, or the reacted fluorogenic agent, or a combination of both signals measured; and

(b) applying the optimal amount of biocontrol treatment to the membrane separation system.